

AUTOMATED SMALL-CRACK MONITORING SYSTEM

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MOTIVATION

- **Differences between small and long crack behavior complicates fatigue life prediction**
 - Database generation using long crack coupons
 - Applied to small crack problems
- **Using small crack data would be ideal**
 - Obtaining small crack data is time consuming and labor intensive
 - Automated system would improve efficiency

REPLICATION METHODS

- Replicas of specimen surfaces periodically taken
- Crack length determined by replica examination at high magnification
- Advantages
 - Well-established
 - Documents damage state of an instant in time
- Disadvantages
 - Labor intensive
 - Replica medium may affect crack growth



Acetate tape replica



Silicon-based replica

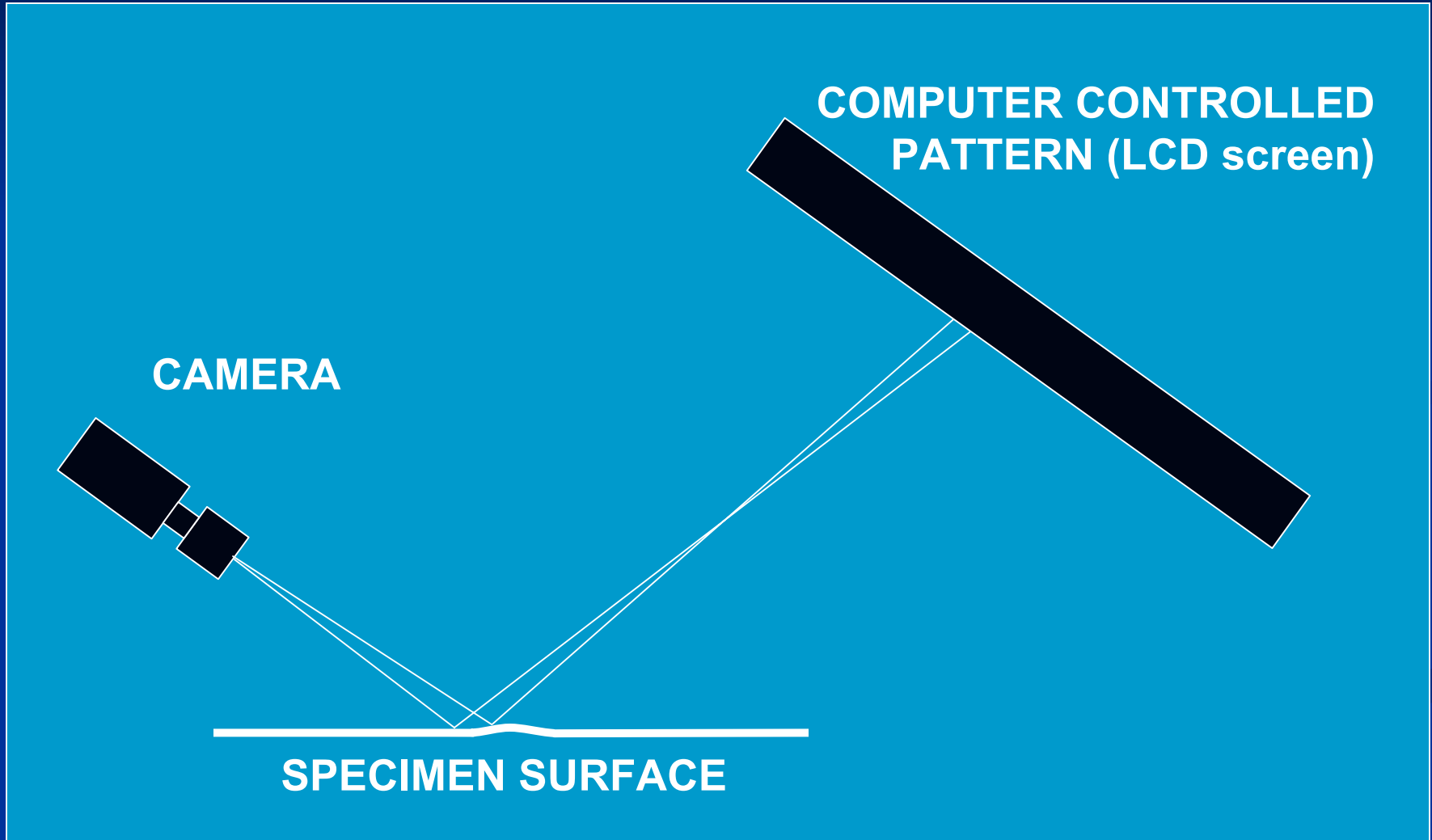
OBJECTIVES

- **Develop a non-interfering automated crack detection system**
 - Track crack length during test
 - Generate *a*-versus-N data
 - Find/track small cracks as small as 25 μm (0.001 inch) in length
- **Provides “natural” crack growth rate data**
 - Avoids concerns associated with long crack testing

APPROACH- System Development

- Digital imaging used for laboratory experiments
 - Strain fields
 - Crack closure
- Non-contacting and does not affect environment
- Capture and store digital images of specimen gage section periodically during test
- Crack length determined from digital images

SMALL CRACK MONITORING SYSTEM



APPROACH - Verification

- Perform small-crack-growth tests on well-characterized materials
 - Periodically replicate specimen surface
 - Compare crack length from automated system with results obtained from replicas
 - Compare FCG data (da/dN -versus- ΔK) from automated system with trusted results

SMALL CRACK MONITORING SYSTEM

■ ADVANTAGES

- Better simulates real small-crack service conditions**
- Provides a record of damage history**
- Automated**

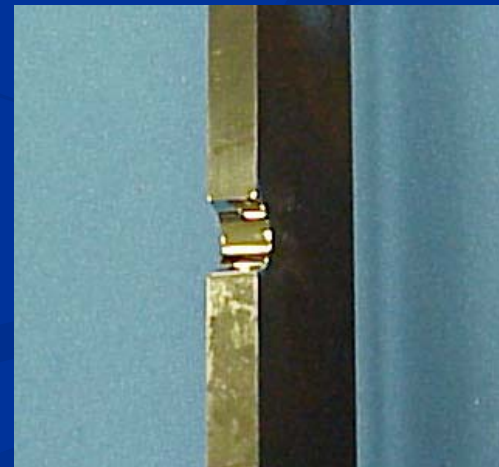
■ DISADVANTAGES

- Specimen preparation**
- System is unproven (Will it always work?)**

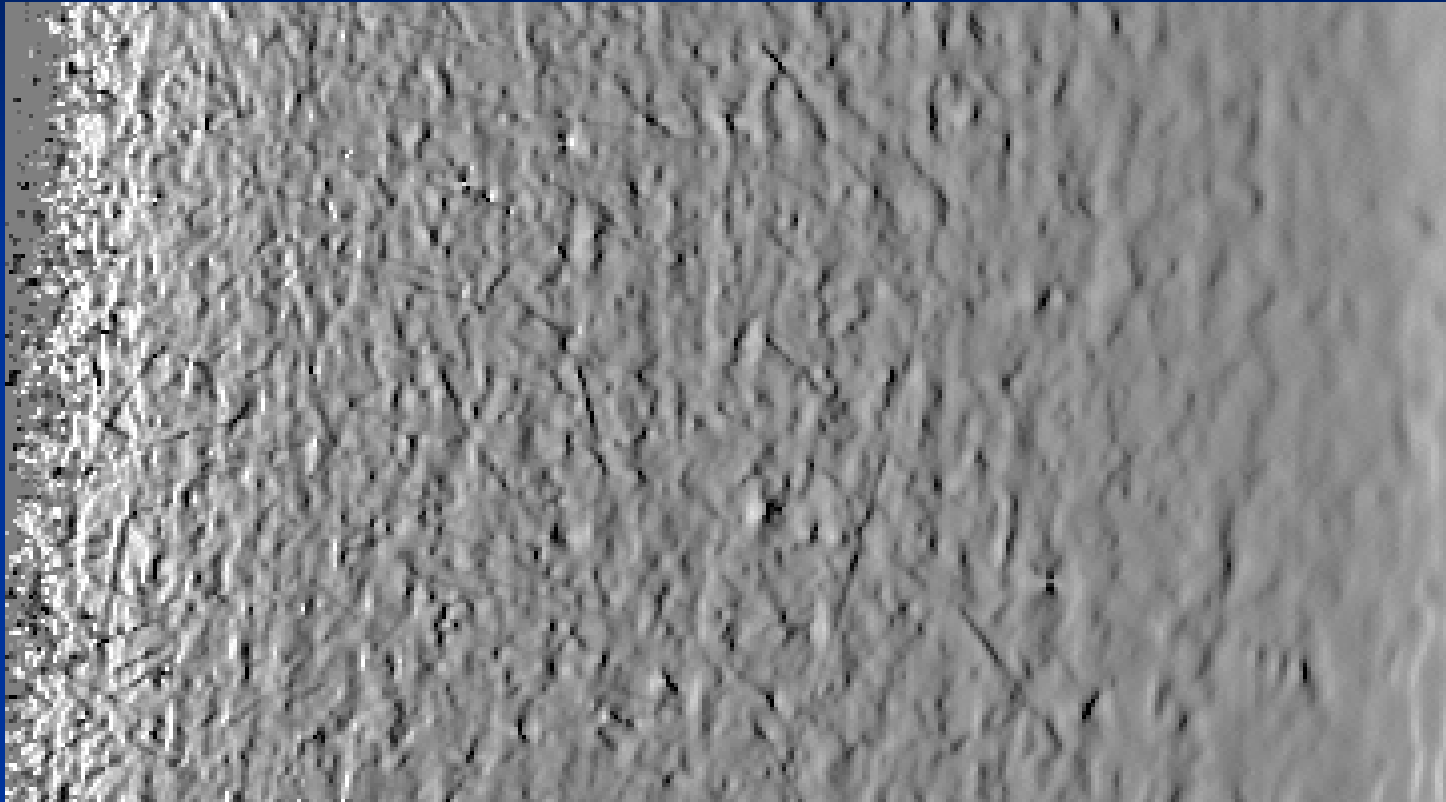
PRELIMINARY RESULTS



- Aluminum alloy 2024
 - Specimen with notch ($k_t = 3.3$)
 - Highly-polished notch surface
- Cyclic loads – 4,400 lbf to 100 lbf
 - Maximum notch stress – 58 ksi



10,000 Cycles

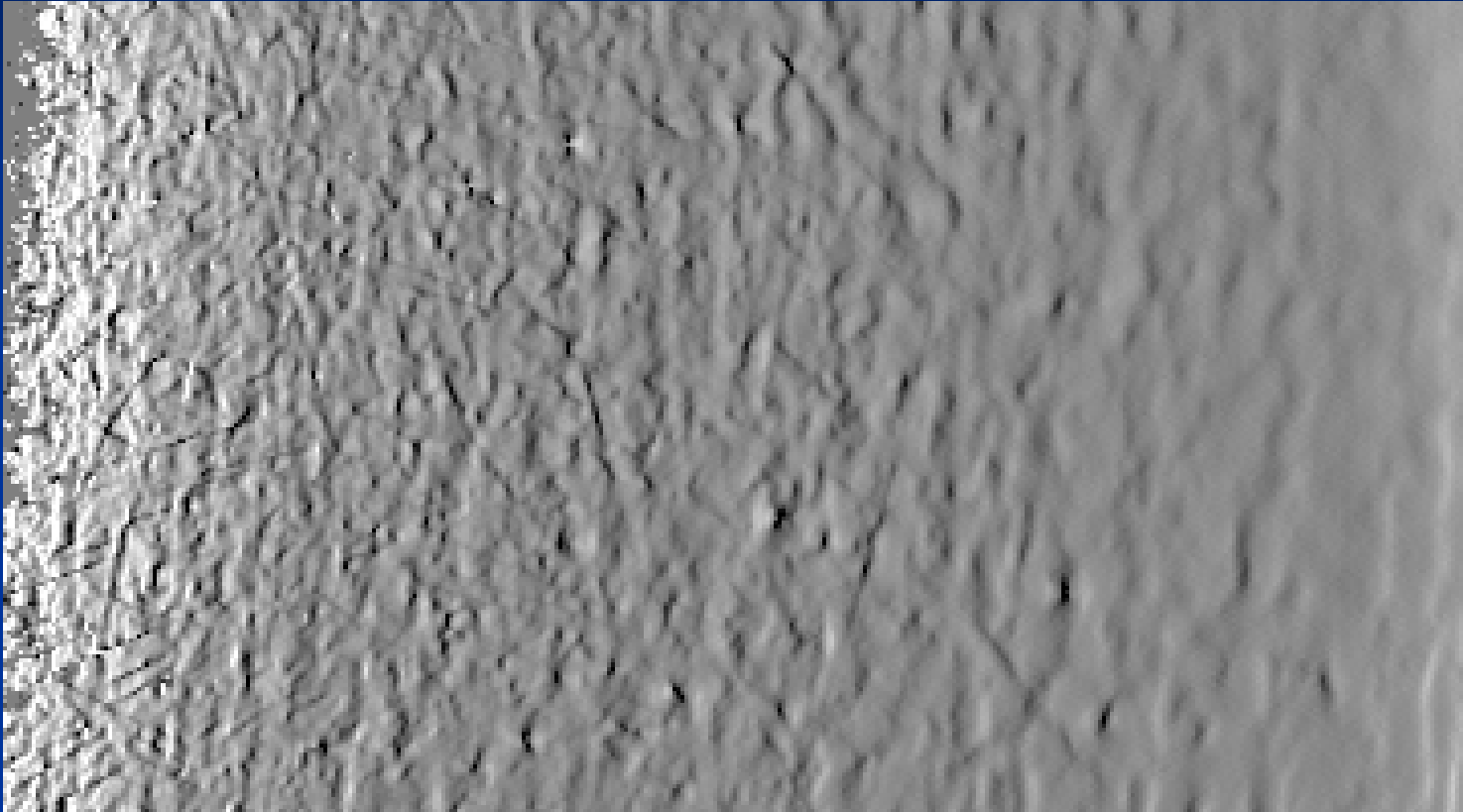


Specimen edge

1/8"

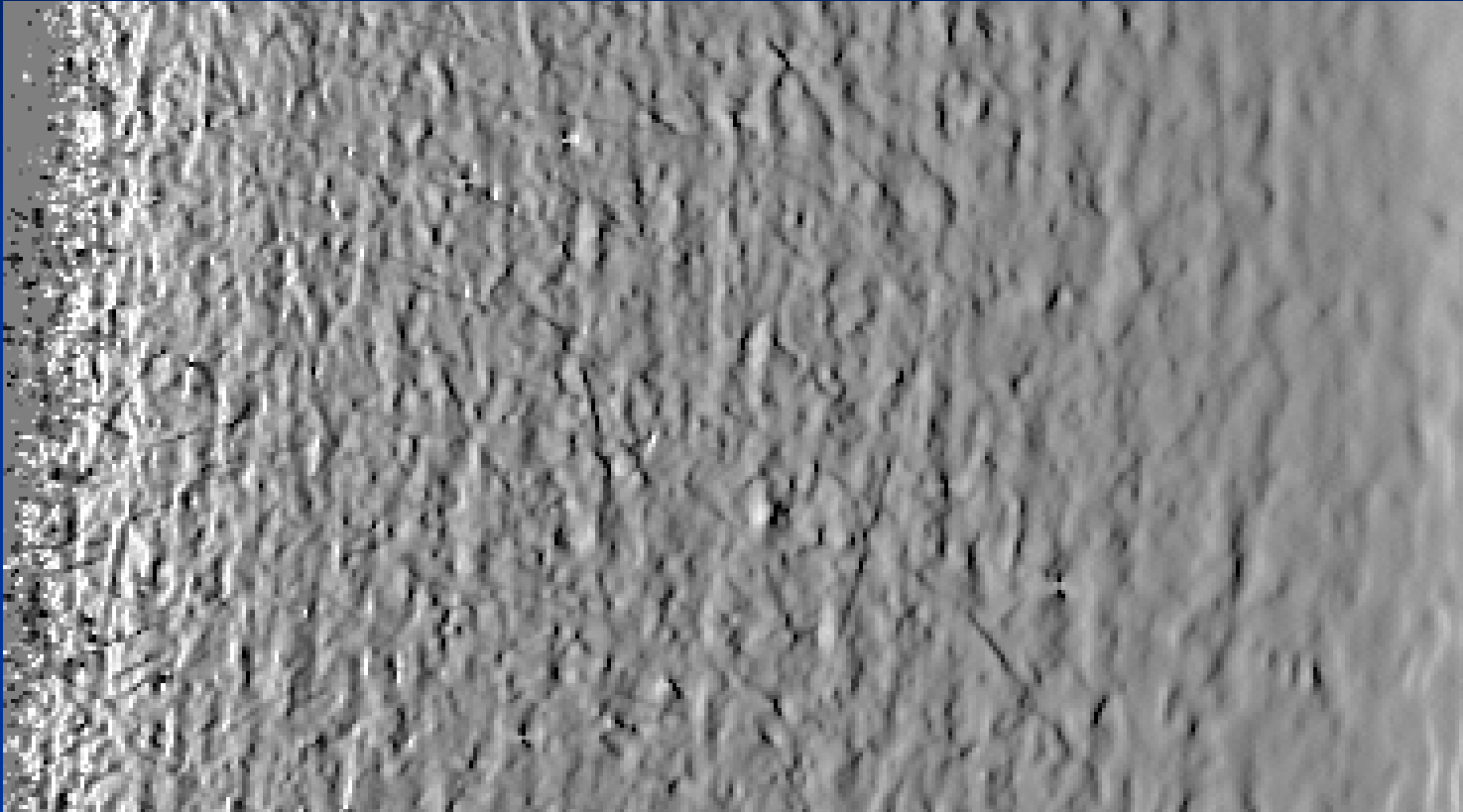
No visible damage

20,000 Cycles



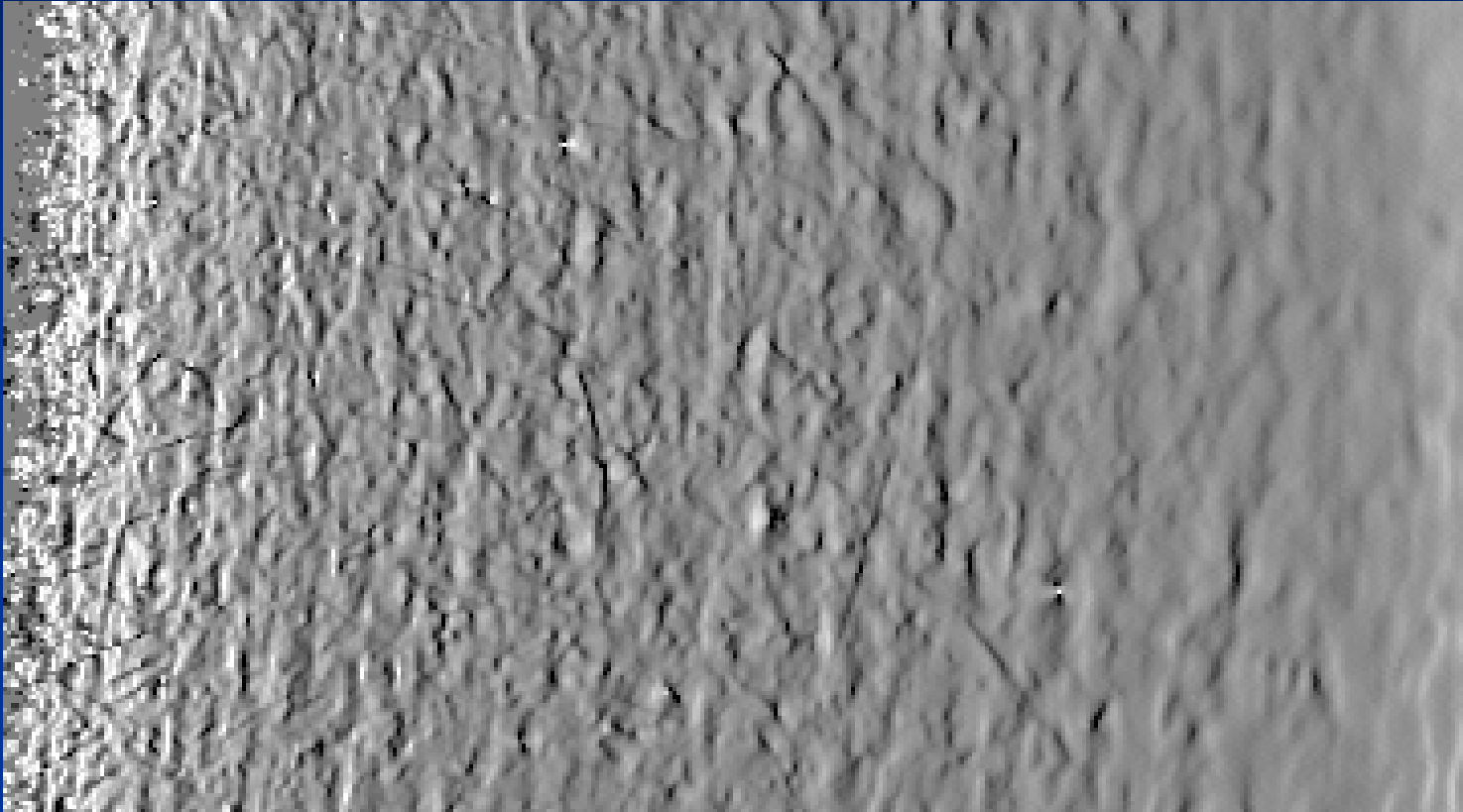
No visible damage

25,000 Cycles

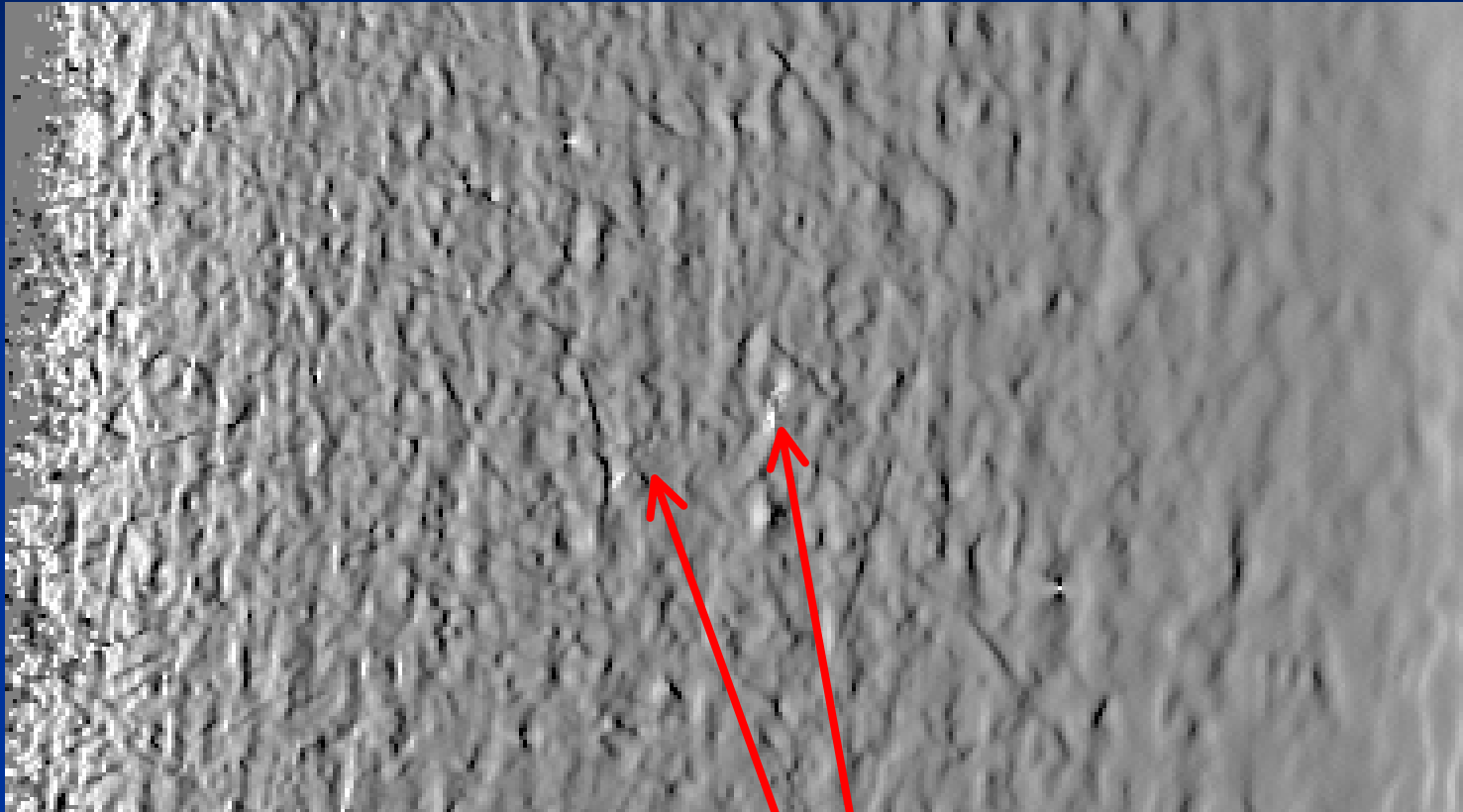


No visible damage

30,000 Cycles

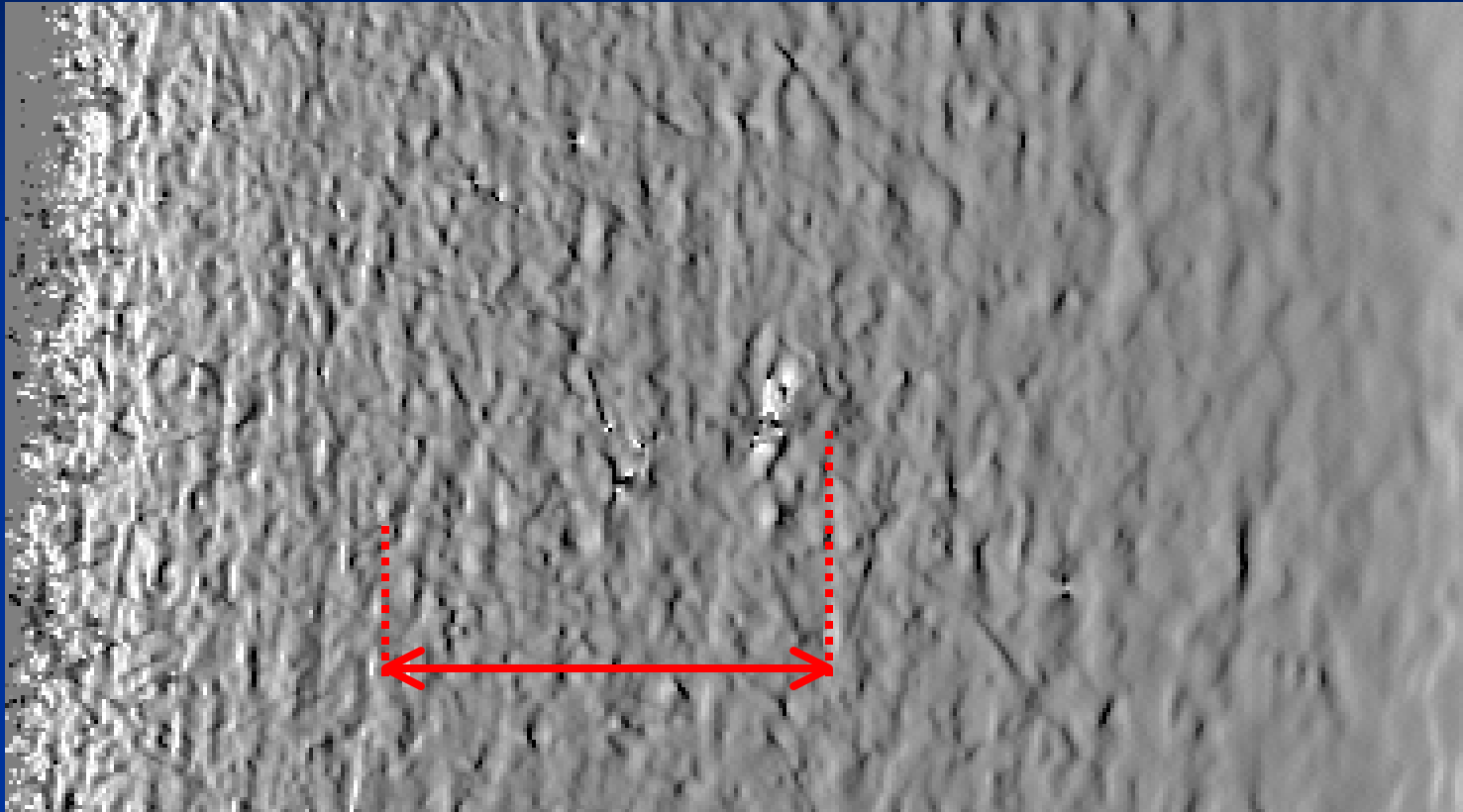


35,000 Cycles



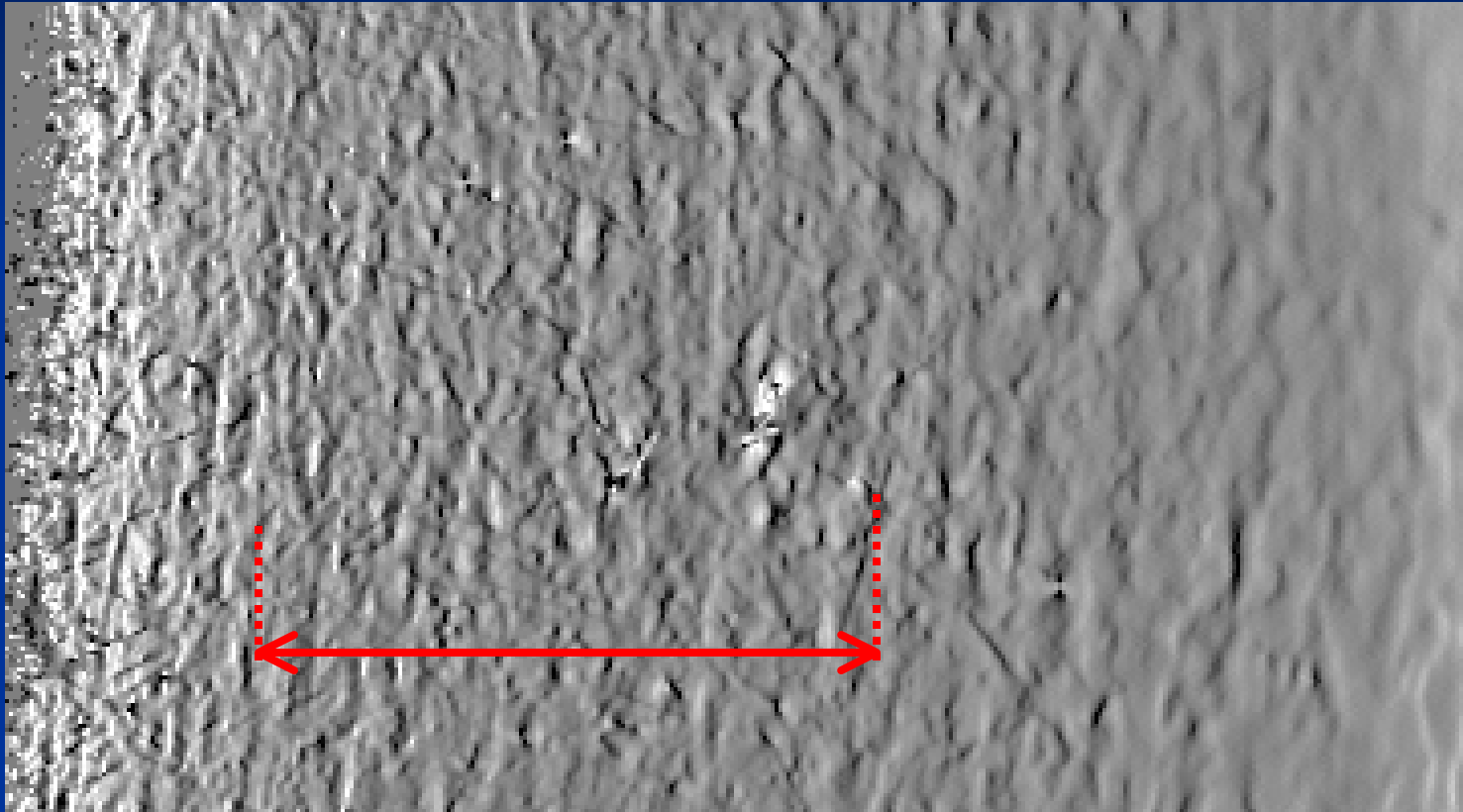
Crack initiation sites

40,000 Cycles



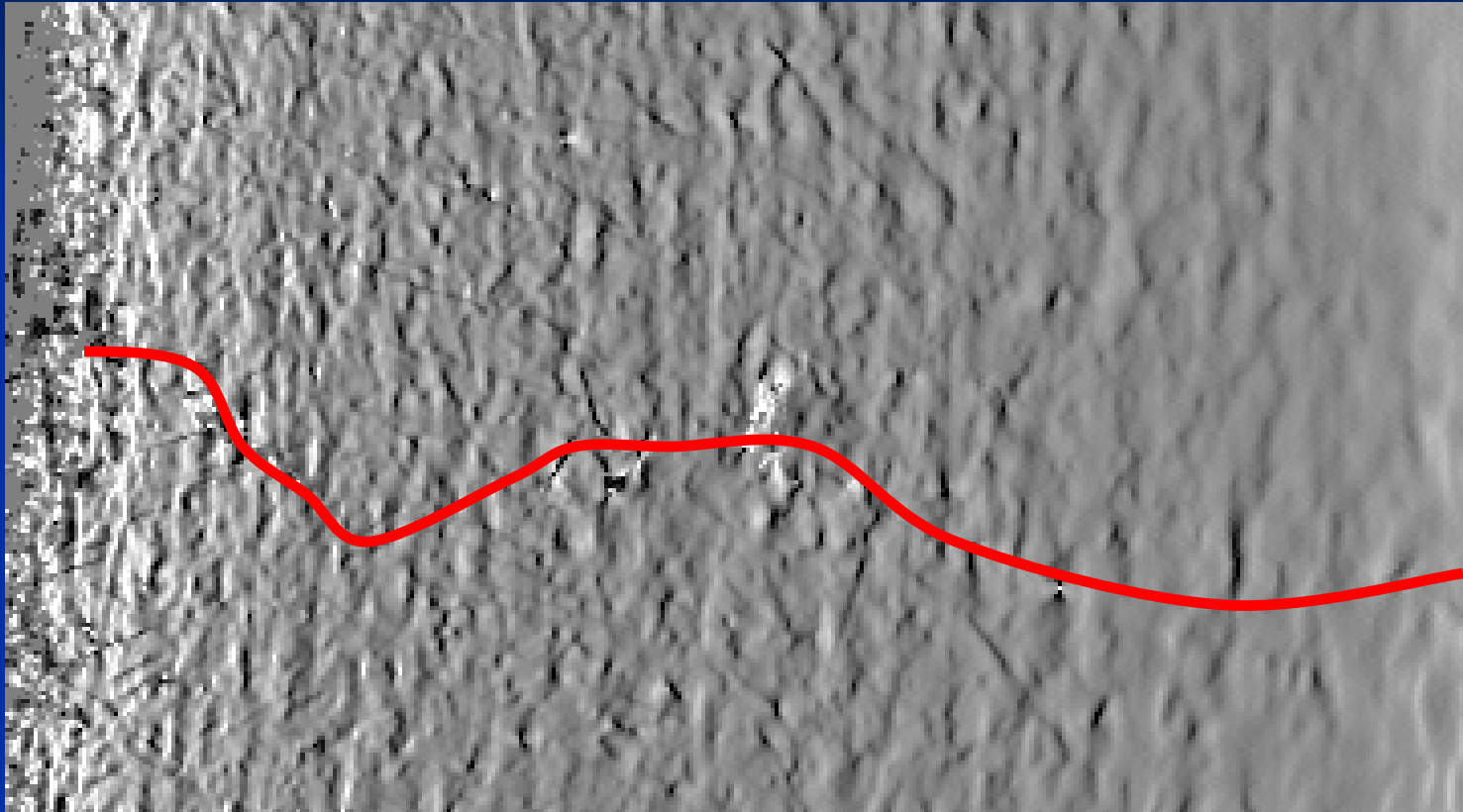
Crack (approx. 0.050")

42,000 Cycles



Crack ($> 0.075''$)

45,000 Cycles



At 45,000 cycles, crack spans entire width.

SUMMARY

- Results show the system can detect and track small cracks in 2024 aluminum
- Preliminary testing conducted on 4340 steel
- Tests are planned to verify system
 - Well-known alloys
 - Compare results with trusted databases and replicas
- If outcome of testing is favorable, this system should provide a relatively easy method of obtaining small crack data